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U.S. EPA Researchers Study Safety Levels of In-house Shelters

A study by researchers from U.S. EPA's National Homeland Security Research Center (NHSRC), in conjunction with the EPA's Indoor Environment Management Branch, has shown that proper sealing can make a substantial difference in the effectiveness of residential "safe havens," or in-house shelters. These shelters could be needed to protect the public in the event of an accidental or intentional release of a hazardous contaminant.

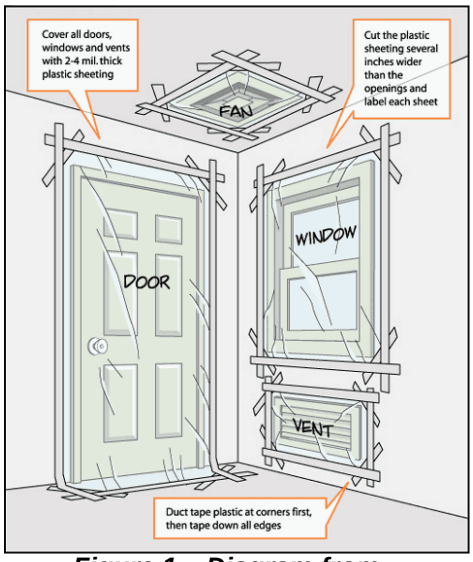

Figure 1. Diagram from www.ready.gov web site

Background

The U.S. Department of Homeland Security (DHS) has recommended residential protective measures to use in the event of airborne contamination (see Figure 1). They include (1) locking doors, closing windows, air vents and fireplace dampers; (2) turning off fans, air conditioning and forced air heating systems; (3) going into an interior room with the fewest windows; and (4) sealing all windows, doors and air vents with plastic sheeting and duct tape. (These recommendations can be found at www.ready.gov.) To test the efficacy of these actions and determine protection levels, NHSRC researchers developed an improved method to determine the air flow rate for an in-house shelter and tested the DHS guidelines in a residence.

Measurement Parameters

Researchers measured air flow rates in the house and shelter under various conditions to determine protection levels. A protection factor is defined as the ratio of the outdoor exposure over the indoor exposure for the house or shelter. For example, a protection factor of 1 indicates the same exposure outdoors and indoors, but a protection factor of 10 indicates 10 times greater exposure outdoors than indoors. Protection factors, ranging from 1.3 to 539, were calculated using various occupancy times, weather conditions, and outdoor exposure times for hazardous agents. It was found that the shelters reduced peak concentrations in all scenarios, but that the protection level decreased as the occupancy time increased. Simulated hazardous agent concentrations outdoors, in the house, and in the shelter were evaluated, as illustrated in

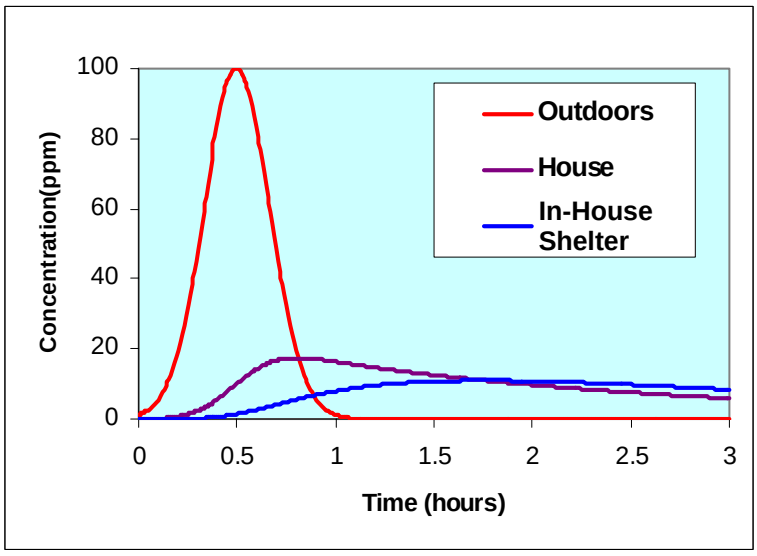

Figure 2. Simulation for a 1-hour outdoor exposure

Figure 2. It shows an outdoor exposure time of one hour with an air exchange rate for the house of 0.5 air changes per hour and an air flow rate between the house and shelter of 14 cubic meters per hour. Exposure is illustrated as the areas under the concentration curves. Protection factors may be estimated by comparing the area under the outdoor concentration curve to the areas under the concentration curves for the house and shelter.

Simulations involving carbon dioxide (CO_2) and oxygen (O_2) concentrations within an occupied shelter were evaluated over time, using the lowest measured air flow rate. Results showed that increasing CO_2 concentrations and decreasing O_2 concentrations would be tolerated for up to approximately three hours by most people, but could affect individuals with respiratory problems. More dangerous conditions could result as conditions change, such as increased occupancy, a lower air flow rate, increased carbon dioxide emission rates and oxygen consumption rates due to increased activity, or a longer occupancy time.

Results

Using guidelines outlined by the DHS, the researchers found that the recommended sheltering measures – plastic sheeting and duct tape – are most effective if individuals remain inside the shelter only until outdoor hazard levels are less than levels inside the shelters. Staying inside the shelter any longer decreases the protection factor. It was also found that sheltering in place can be detrimental if people enter or exit shelters too late. Individuals receive the greatest benefit if they enter shelters before the arrival of hazardous contaminants and exit them as soon as the contaminants dissipate outdoors.

Future Actions

Results of this study have been presented to the DHS and the U.S. Senate Sergeant-at-Arms. Further research will be necessary to evaluate the effectiveness of shelters appropriate for use with public buildings.

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